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*Published in:*
Sustainability

*Link to article, DOI:*
10.3390/su11133727

*Publication date:*
2019

*Document Version*
Publisher's PDF, also known as Version of record

*sustainability*

MDPI

*Article*

# Configuring New Business Models for Circular Economy through Product–Service Systems

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Received: 6 June 2019; Accepted: 5 July 2019; Published: 8 July 2019


**Abstract:** Product—service systems (PSSs) are often outlined as potential enablers of new business models for circular economy. However, not all business models based on product-service systems have superior circularity potential. This research demonstrates how the application of a previously developed business model configurator for circular economy can support the design and assessment of customer value, economic and resource decoupling potential for product-service system business models in practice. By applying action research in two Nordic manufacturing companies from the furniture sector, different business model concepts based on product-service systems were proposed and assessed. Results indicate positive uptake by companies regarding the usefulness of the obtained outcomes. This research identified two key findings about 'product-service system business models for circular economy': (i) their configuration should fulfil certain simultaneous conditions—i.e., superior customer value, economic growth, and resource decoupling potential—to contribute to circular economy; and (ii) they are often *'niche solutions'*, fulfilling specific needs and customer segments, and more likely to flourish with certain types/characteristic of products, segments or geographical locations. Lastly, a framework outlining the conditions and trade-offs for assessing the circularity potential of business models based on product-service systems is introduced as one of the key contributions.

**Keywords:** business model innovation; circular economy; product-service system (PSS); configuration; action research

## 1. Introduction

Circular economy (CE) aims to establish a resource-effective and efficient economic system that is more suitable to respect planetary boundaries [1]. CE is often interpreted as one way of achieving economic and environmental sustainability [2], but it also has potential to generate secondary positive effects on the social sustainability perspective [3,4]. To implement CE principles, societal, industrial, and consumption systems will need to shift their foundations to build on renewable energy/materials sources and to reduce waste generation [5] by intentionally narrowing, slowing, and closing material and energy flows [6].

For manufacturing companies, the adoption of CE as a business strategy implies striving to provide and maintain products with the highest value while consuming as few resources as possible [7]. The main idea is to fight against structural waste [5] caused by inherent ineffectiveness of value systems due to bad design (e.g., fast obsolescence), sub-optimal processes, outdated laws, lack of motivation or unconcerned behavior from receivers (e.g., overconsumption or misuse of products) [5,7]. Hence, building organizational (or even interorganizational) capabilities for CE requires as much technological or product innovation as systemic value innovation with the configuration of new business models (BM) which are fit with CE principles [8,9].

A business model for circular economy is defined as "how a company creates, captures and delivers value, with a value creation logic designed to improve resource efficiency through contributing to extending the useful life of products and parts (e.g., through long-life design, repair and remanufacturing) and closing material loops" [10] (p. 13). Product-Service Systems (PSS) are often outlined as one of the potential enablers for configuring new business models for circular economy, stimulating life-extension and product take-back [10–16]. However, PSS- or CE-oriented approaches do not necessarily lead to a reduction in resource consumption or automatically guarantee enhanced environmental or social sustainability [3,17–20]. Despite the availability of an increasing amount of academic content and approaches for BM innovation for CE (including PSS as a strategy) [9], developing resource-efficient and effective business models based on PSS offerings is still reported as challenging for companies [13,21,22]. The main challenges during the design and assessment stages faced by organizations are related to: (i) applying efforts systematically to reinvent the logic of how their business works to simultaneously achieve economic and resource effectiveness/efficiency goals [12]; and (ii) transferring conceptual knowledge/learnings about PSS and circular economy to the real-world practice in an effective, useful, and simple approach [9,23].

The main objective of this research is to reduce these challenges and help organizations in configuring (i.e., designing and assessing) business models for circular economy including (but not limited to) the approach of Product-Service Systems. A previous proposed conceptual process model—entitled the CE-Oriented Business Model Innovation (BMI) Process (documented in [23])—and its accompanying tools were applied and improved in action research cycles with two Nordic furniture manufacturers. The main tool supporting the CE-Oriented BMI Process is the CE-Driven Business Model Configurator (documented in [3]), which intends to guide companies in sensing and making sense of CE opportunities and seizing (or designing and assessing) BMs, based on a number of CE-oriented BM patterns consolidated from reviewing theory and practice (i.e., with retrospective analysis of more than 150 cases). In this research, patterns are defined as the possible combinations of configuration options for the BM elements, which repeatedly occur to enable circular economy principles in companies' business models [24,25]. Different patterns related to PSS are considered in the CE-Driven Business Model Configurator, along with other patterns not necessarily related to PSS. The focus of this article is to show how the application of the configurator supported the design and assessment of the customer value, economic potential, and resource decoupling potential of PSS business models in practice.

The following sections of this article explain the research method (Section 2), describe the application of the selected conceptual process model and tools in the action research cycles with two furniture companies (Section 3), discuss the key findings and insights (Section 4), and present conclusions and future research steps (Section 5).

## 2. Research Method

This section contains two subsections. The first subsection introduces the research approach, including method and materials. The second subsection provides an overview of the conceptual framing—a process model and the main tool applied in the action research cycles for supporting the companies in configuring CE-oriented BMs based on PSS.

### *2.1. Research Approach*

Inspired by aspirations in Management and Design Sciences of promoting 'impactful' academic research, which is able to demonstrate the contribution made 'to' and 'with' business [26,27], this research adopts action research (AR) as methodology. AR is a form of applied research (or engaged scholarship [28]) that combines scientific methods with organizational knowledge, involving the active collaboration of researchers and companies' members to propose solutions to real organizational problems while building theory from observing and interacting with practice [29]. Originated in the Social Sciences, AR has been recognized as an appropriate research method in various fields [30–33].

There are several AR approaches and ways of combining them with other methods [31]. This research followed the overall guidelines proposed by Mathiassen [29] and applied a four-step cyclical process [33] for data collection and analysis.

First, two companies (Ope and Vestre) were selected for the action research according to three criteria: (i) furniture manufacturer in the Nordic region; (ii) intention to explore or start their transformation towards CE from a business model perspective and focus on PSS; (iii) availability/willingness to provide access to processes/people, share information and provide feedback during the ARs. The furniture sector was selected in this study due to its economic representativeness for the European Union (EU) and Nordic markets, the environmental challenges and potential opportunities in a CE context. One-third of furniture commercialized globally comes from the EU, contributing to approximately 1 million jobs, predominantly in small- and medium-sized enterprises (SMEs) [34]. It is estimated that there are 130,000 furniture companies in the EU [35], and approximately 3,000 in Nordic countries [35–37]. Most furniture (around 80–90%) in the EU is destined for landfill when reaching the end-of-life, with only 10% being recycled [34]. Practices for extending the life of furniture (e.g., reuse or remanufacturing) are limited to a small scale. Concerned with such a wasteful and ineffective environmental (and sometimes even economic) scenario, researchers and practitioners have been exploring solutions to improve the furniture sector. CE and PSS are indicated as promising approaches to this end [34,38,39].

The second step in this research entailed the selection of a process model (CE-Oriented BMI Process [23]) along with its tools (the main tool is the CE-Driven Business Model Configurator [3]) to act as conceptual framing for guiding the development of PSS business models for CE in the AR cycles (described in Section 2.2).

As the third step, the test and refinement 'in action' of the proposed CE-Oriented BMI Process and the CE-Driven Business Model Configurator were planned and executed with each company in workshops that occurred within a period of one month. The workshops received up to six participants and included key decision-makers from different functional areas (detailed in Section 3). Data collection methods to evaluate the application of the CE-Oriented BMI Process and the CE-Driven Business Model Configurator comprised a journal with the researcher's observations and post reflection; recordings of the workshops to enable the compilation of comments and verbal feedback; and structured evaluation questionnaires standardized for all companies and answered by the participants at the end of each workshop. The questionnaires comprised a combination of multiple-choice and open-ended questions that aimed to measure the usefulness and usability of the process model and tool in three aspects: (i) overall process and main activities; (ii) results obtained against the proposed outcomes; and (iii) results obtained against expectations. The object of measurement in the questionnaires was satisfaction (i.e., how the process model and tool are perceived as successful by the company). A 4-point Likert scale varying from 'Unsatisfactory' to 'Very satisfactory' [40] was employed as options for answers.

Lastly, the collected data from the research journal, recordings and questionnaires were analysed to enable the evaluation of the application of the process model and tools in the companies, resulting in the identification of improvement opportunities (catalogued following a coding process) for the process model and the tool to be applied in future research.

### *2.2. The CE-Oriented BMI Process and the CE-Driven BM Configurator*

The CE-Oriented BMI Process [23] comprises three stages based on the dynamic capabilities view [41]:

1. Sensing and making sense of CE opportunities in the ecosystem;
2. Seizing the opportunities by designing and assessing new CE-oriented value generation architectures (i.e., CE-oriented BM concepts); and
3. Transforming/renewing operational capabilities accordingly in order to implement the CE-oriented BMs.

The process model allows a holistic approach to companies, in the sense that it suggests activities from design to implementation of CE-oriented BMs [23]. Moreover, it allows a systemic approach that integrates four tangible and intangible perspectives for CE-oriented BM innovation: (i) activities and tools; (ii) business processes and sustainability performance interdependence; (iii) strategic decision-making procedures; and (iv) consideration of social traits and capabilities [23]. The main tool supporting the process model is the CE-Driven BM Configurator [3], which will be the focus in the remainder of this article. Figure 1 illustrates how the Configurator supports the CE-Oriented BMI Process and interacts with the other supporting tools. Figure 2 illustrates details about the interfaces and logic of the Configurator.

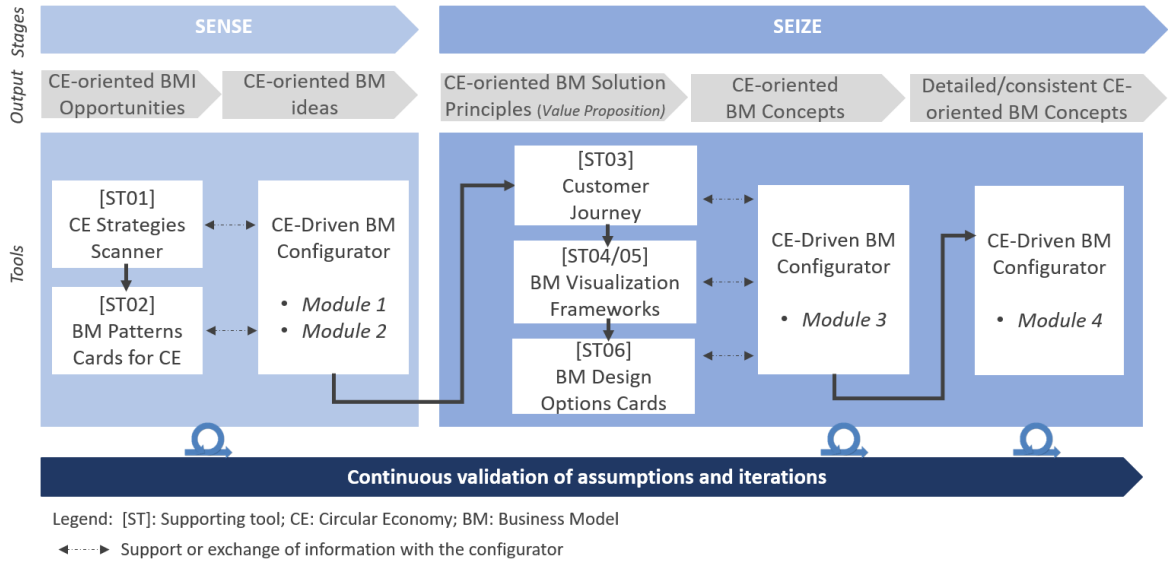


**Figure 1.** Extract from the first two stages of the CE-Oriented BMI Process including expected outputs, supporting tools and the link with the CE-Driven BM Configurator. BMI: Business Model Innovation.

The Configurator supports BM design for CE based on patterns. A pattern is interpreted in this work as a combination of configuration options for the BM elements, which repeatedly occurs in successful BMs for CE [24]. Although a few works apply pattern-based approaches for designing BMs for PSS [42,43], they are still addressing CE superficially. For instance, in Kwon et al. [43], less than 3% of the available configuration options (3 out of 53) for PSS BMs design are related to improving resource efficiency or effectiveness. There is one work applying the pattern-based approach for CE [25]; however, it is still conceptual (i.e., lacking clarity about how the implementation of the framework could occur in practice) and generic (i.e., lacking sectorial specificity or contextualization, which is relevant for CE [26]). Lastly, they lack clarity about the combination of multiple patterns, which is necessary to the complete design since a pattern usually addresses different parts or elements of the business model [24,44]. The CE-Driven BM Configurator tackles those gaps and advances knowledge in respect to the aforementioned research by:

- Facilitating the proposal of business models based on PSS and with a focus on CE, including patterns that address economic and resource decoupling problems/opportunities (Section 3.2);
- Enabling practical application and providing guidance on how to use and combine the patterns along the stages of ideation, design, and evaluation of business models for CE, including simulation of different configurations (scenarios) (Figures 1 and 2; and Section 3.2);
- Introducing a sectorial contextualization to enable more precise and in-depth business model configurations for CE.

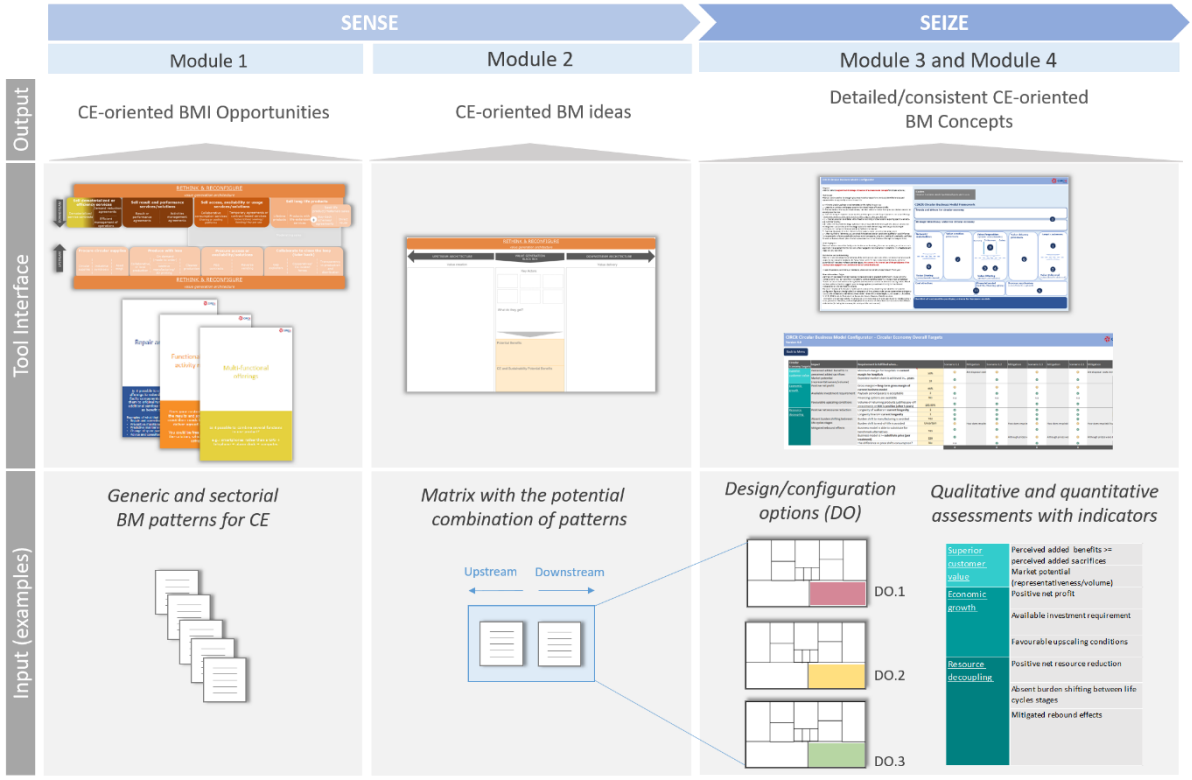


**Figure 2.** Initial version of the CE-Driven Business Model Configurator (adapted from [3]).

Inspired by previous research in the PSS field [45], the Configurator is a planning tool suited for the early stage of when manufacturing companies decide to move towards BMs for CE. The purpose is to trigger a change of mindset towards CE by acting around the dynamic capabilities concept (individual managerial and organizational skills) [41]. CE will require 'breaking industry recipes' [46] and the silo/organizational-centric view. However, according to recent research in CE [47], some actor in the value chain has to take the lead and start thinking about CE first internally, then absorb the concepts, and then influence other actors and lead the initiatives that will occur collaboratively. The Configurator seeks to incentivize more of those individual actors acting in the position of manufacturers to change their perspectives and way of operating and inevitably to influence others. Hence, the Configurator starts with the organizational-centric approach (e.g., using BM frameworks that are inheritances from linear economic logic or having one company leading the process), but it leads the manufacturing companies to gradually realize the importance of collaborations and the organizational or ecosystem view for CE. For instance, one of the patterns' categories available in the configurator is called 'collaborative value creation with third parties,' and it comprises several actor configurations in the value chains of specific industries (or cross-industries) to guarantee product/material circularity. In the furniture sector, 13 out of 41 patterns address collaborations.

For the initial version, the Configurator was structured in a spreadsheet, which was used as a facilitating tool for the application in the action research cycles, generating information to populate interactive frameworks (e.g., collection of printed patterns in the format of cards, and a printed template for combination of patterns) that were suitable for group discussions and flexible to enable 'live change requirements' (Figure 2).

The Configurator comprises four modules. Modules 1 and 2 are applied during the 'sense' stage of the process model (Figures 1 and 2). Module 1 focuses on the *identification of opportunities* for designing new BMs for CE. It contains a collection of CE-oriented patterns for upstream and downstream BM architecture [3]. Different types of PSS are considered as patterns in the configurator, along with other patterns not necessarily related to PSS (e.g., multi-cash flows originated through industrial symbiosis). These patterns were compiled following previous methodologies for pattern generation in traditional

BM literature [24,44], in two steps: (i) identification and consolidation of previously developed generic patterns of business models for CE available in literature (listed in [9]); and, (ii) retrospective analysis of more than 150 cases in six industry sectors [3]. Furniture is one of the target sectors in the configurator, comprising approximately 35 cases (Supplementary Materials: Table S1). The patterns are presented in the configurator in two formats; a list in an Excel database or as printed cards for interactive workshops (ST02 in Figure 1). Each pattern is accompanied by a definition and examples of real-case applications. In addition to the pattern cards, a template containing a list of possible CE strategies developed from [11,48] and entitled Circular Strategies Scanner (ST01 in Figure 1) is used as a boundary object to organize and combine the patterns.

Module 2 focuses on transforming opportunities into *BM ideas*, which means combining different BM patterns and adapting them to make sense for the company's context. This is grounded on previous research that identified that the majority of BM innovations are outcomes of recombination of existing patterns [49,50]. Module 2 is supported by a matrix with potential combinations of patterns, based on sectorial case studies for CE-oriented BM innovation. This module emerged as a response to an improvement required during the first action research cycle; therefore, it was applied only in the second cycle (i.e., Vestre). After the free ideation exercise in Module 1, Module 2 enables the verification, improvement, or creation of other possible combinations, which will trigger iterations in the initial version generated with the tools ST01 and ST02 (Figure 1).

Modules 3 and 4 are applied during the 'seize' stage of the process model. Module 3 focuses on the *configuration of BM concepts* for CE. It is supported by a morphology [51] organizing the common practice or appropriate design/configuration options according to the selected combination of BM patterns. Different design/configuration options are suggested for each business model element: systemic outcomes (i.e., expected economic, environmental, and social benefits); offerings (i.e., products/services); target customers; value delivered (i.e., benefits for customers); network (i.e., partners and collaborations); value shared (i.e., benefits for network); value delivery processes; value creation processes; revenue mechanisms; cost structure; and financing options [3]. The design options were also available in two formats: a list on an Excel spreadsheet or cards to facilitate group working (ST06 in Figure 1). Module 3 interacts with two supporting tools: a Customer/User Journey Map (ST03 in Figure 1), and two types of visualization frameworks for the BM (ST04/05 in Figure 1). The first visualization framework (ST04) is inspired by Brehmer et al. [52] and illustrates the flow of value exchanged (i.e., offering—which can be either services or products—and economic/social flows) among actors for the BM concept. The second framework (ST05) illustrates the BM concept in a 'traditional' canvas view, and is adapted from Kraaijenhagen et al. [53] and Biloslavo et al. [54], which build on the 'value concept' largely disseminated in traditional BM literature by Osterwalder and Pigneur [55] and Richardson [56].

Module 4 comprises preliminary *assessments of the customer value, economic, and resource decoupling potential* for the designed BMs for CE. The assessment provides both quantitative and qualitative measures. The assessment of customer value is qualitative, based on the evaluation of potential trade-offs of potential benefits and sacrifices perceived by the customers with the new BM concept [57]. The assessment of the economic potential is based on cost-benefit analysis and is structured as a 'business case,' applying both quantitative and qualitative measures. The assessment of the resource decoupling potential is based on the guidelines provided by Kjær et al. [17], also including qualitative and quantitative measures. The selection of indicators to compose the quantitative part of the assessments followed guidelines provided by a tool for screening the sustainability potential of CE initiatives [58].

## 3. Action Research Cycles and Their Results

This section presents the results in two subsections. The first subsection introduces the dynamic of the action research cycles and the context of the participating companies. The second subsection explains the application of the configurator and the obtained CE-oriented BM concepts based on PSS.

### 3.1. The Companies Participating in the Action Research Cycles

This subsection describes the dynamic of each action research cycle as well as the context of the participating companies Ope (AR cycle A) and Vestre (AR cycle B).

#### 3.1.1. Action Research Cycle A

This action research cycle occurred during July 2018 in the company Ope, which is a small Norwegian furniture manufacturer with headquarters in Stavanger. In addition to the main author of this research, the workshops for application of the process model and tools engaged between two and six participants from Ope, including the Sales & Operations Manager (all workshops), an external consultant working with strategy and innovation (all workshops), Marketing and Sales Coordinators (workshops 1, 2 and 5), Product Design Manager (workshop 5) and a Board member (workshop 5).

Ope already presented some capabilities that are expected for CE, for instance, product design. The company offers dynamic and modular furniture systems, allowing the creation of working/living spaces. These are premium products manufactured by third parties, assembled in-house and currently sold by Ope to the business-to-consumer (B2C) segment via their web store and to the business-to-business (B2B) segment via direct sales or partners. Since the products are modular, it is possible to customize (within a range of predefined options) the size of the systems, upgrade them or order additional accessories. The product comprises two key parts, MDF panels and plastic connectors. The technology for guaranteeing the system's modularity was developed and patented by Ope and is fundamental for allowing multiple cycles of disassembly and assembly during use.

Ope had previous knowledge about the concept of CE and sustainability. They were aware that some of their product's characteristics (i.e., modularity and upgradability) could favor and facilitate the implementation of BMs for CE, especially PSS. They also acknowledged some challenges, such as the presence of 'non-circular' components in the composition of the product (e.g., MDF and plastics), lack of formalized life-extension or end-of-life services, no return or 'pro-active action' with the products when they reach end-of-use or absolute end-of-life. Furthermore, they had limited experience with additional basic services for product life-cycle extension occurring in an informal and ad hoc approach (e.g., repair and maintenance, refurbishment services, buy-back scheme). Ope was developing a new product for short-term events, also designed with modular technology. Due to the challenges and the potential (even) shorter usage cycles of the new products, there was a particular interest in exploring different PSS BMs, in order to understand the changes required in their business capabilities and the impacts on resource decoupling and economic outcomes.

#### 3.1.2. Action Research Cycle B

This action research cycle occurred during January 2019 in Vestre, which is also a small Norwegian company with headquarters in Oslo. In addition to the main author of this research, between one and three participants from Vestre were engaged, including the Sustainability and Strategy Manager (all workshops), the Marketing Manager (workshop 1), and the Product Manager (workshop 1). Although only one participant appointed by the company was present in workshops 2 and 3, internal validations of the results were conducted with the other collaborators, which also supported data collection (especially for the calculations in workshop 3) after each workshop and before they replied to the evaluation questionnaire.

Vestre offers outdoor furniture to allow the creation of social meeting places. They have a varied portfolio of premium products manufactured in-house and currently sold in B2B and B2G (business-to-government) segments. The different products are mainly composed of wood and stainless steel. Due to their application in outdoor spaces, design for durability is key to ensure resistance to harsh climate conditions (e.g. wind, rain, sun exposure). The company provides a guarantee on materials, which highlights the importance of the reliability of their products.

Vestre also had previous knowledge about the concept of CE, with a higher focus on the wider scope of environmental and social sustainability. Nevertheless, they were unsure about how they could apply their products' characteristics (e.g., durability) to seize new business models for CE. They also acknowledged a number of challenges, such as: the need to redesign the products to facilitate disassembly or repair; potential difficulties with recyclability or biodegradability due to the presence of toxic materials (e.g., lacquer impregnation and coating used in galvanization); specific requirements from customers potentially hindering the acceptance of CE BMs; and no return or 'pro-active action' with the products when they reach end-of-use or absolute end-of-life. Recently, they have received new requests from customers for products' life-extension services (e.g., refurbishment including re-coating and maintenance). Moreover, they identified the opportunity for increasing market share in a specific segment by providing products as services and greener solutions. Due to both trends, Vestre had interest in exploring different PSS BMs to understand the changes required in their business and the impacts on resource decoupling and economic outcomes.

### *3.2. Application and Results of the CE-Driven BM Configurator for Designing and Assessing CE-Oriented BMs Based on PSS*

This section explains the application of the Configurator and the configured CE-oriented PSS BMs as outcomes for each action research cycle.

#### 3.2.1. Action Research Cycle A

The first module of the configurator was applied in a 3-4 hour workshop with the use of the supporting tools (Figure 1). The Circular Strategies Scanner (ST01 in Figure 1) inspired a free brainstorming with the participants working in a group. The aim was to create new CE-oriented BM ideas based on their experience. After the free brainstorming, the participants received a set of cards with the BM patterns for CE (ST02 in Figure 1) to inspire themselves with real cases featuring different BM patterns (including but not limited to PSS) to enable different initiatives for CE in the furniture sector. The cards were investigated by the group, leading to the creation of eight BM ideas that were added to the Circular Strategies Scanner, of which three were based on PSS (Table 1).

**Table 1.** CE-oriented BM ideas for PSS generated by Ope.

| BM Idea | BM Opportunities (Patterns) | Customer Value Potential | Structural Waste Source/Type | Decoupling Potential (based on [17]) |
|---|---|---|---|---|
| 1—'Digital platform to facilitate access to/or use of modular furniture systems through short-term contracts.' | 1—Access-based solution (use-oriented PSS) | Customer segments (especially B2B) requiring lower total cost of ownership and higher flexibility (e.g., such as project-based organizations); convenience of frequent customization and aesthetic changes required (styling of offices, fairs and events). | 'Real' product-life shortened—i.e., consumption patterns/use causing inferior longevity than design specifications. | Reduce the need to produce new products to fulfil needs. |
| 2—'Furniture bank—digital platform to enable 'depositing furniture in one location and taking out in another place' | 2—Access-based solution (use-oriented PSS) | Customer segments (especially B2C) requiring temporary solutions (e.g., exchange workers) or having dynamic lifestyle (moving frequently to different geographical locations). | 'Real' product-life shortened—i.e., consumption patterns/use causing inferior longevity than design specifications. | Reduce the need to produce new products to fulfil needs. |
| 3—'Optimal workspaces/ people's environment.' | 3—Functional-based solutions with complete life-cycle services (result-oriented PSS) | Offices, particularly the ones adopting open-space structures. | Unnecessary configurations/amount of products; 'Real' product-life shortened—i.e., consumption patterns/use causing inferior longevity than design specifications. | Displace more resource intensive systems. |

Ope prioritized the BM ideas to identify the ones to focus first in the stage 'seize' (modules 3 and 4 of the configurator). After an initial discussion, the participants reached consensus and selected 'BM idea 1' due to two criteria (company's choice): (i) *lower service dependence when compared to other alternatives*; (ii) *less complexity and effort (or time) to develop*. 'BM idea 2' would require the expansion of the available furniture portfolio to provide convenient and comprehensive solutions for customers.

This would probably require collaboration with other furniture manufacturers or the creation of new product lines, which would require long-term for implementation. 'BM idea 3' would require the development of new service-oriented capabilities, related to the actual operation and users' behavior in offices (e.g., ethnographical and user-centered design) not available today.

During the second workshop, Ope applied the third module of the configurator (as aforementioned, module 2 emerged as an improvement after this AR cycle). Module 3 enabled detailing the value proposition and identifying new capabilities required for the new PSS concept. As in the previous module, a free brainstorming was performed in order to create the scenario for the new Customer/User Journey (ST03 in Figure 1). Finally, the business model concept was detailed in two types of visualization frameworks (ST04/05 in Figure 1).

In the initial BM concept proposed by Ope (Figure 3), companies (that are seeking temporary workspace or event solutions) would be able to access and temporarily use the furniture by either subscribing to a service package or agreeing on a determined rental/lease contract directly from the provider's digital platform (application). After using the furniture during the agreed period, the products would be pick-up by the providers, who could facilitate the reuse of system(s) in other nine users/cycles before moving them back to the regional refurbishment/remanufacturing center. With the support of the configurator, Ope identified new required operational capabilities (detailed in Supplementary Materials: Figure S1) to implement this concept. For value creation and delivery, they will have to develop skills for service delivery and build a marketplace including digital capabilities and logistics operations. Collaborations with service providers or dealers will be fundamental to enable these capabilities. Moreover, facilities for recycling and coalitions for collecting ocean plastics will need to be established. Lastly, financing enablers are required, for instance, the possibility to collaborate with existing customers for sharing risks and initial investments.

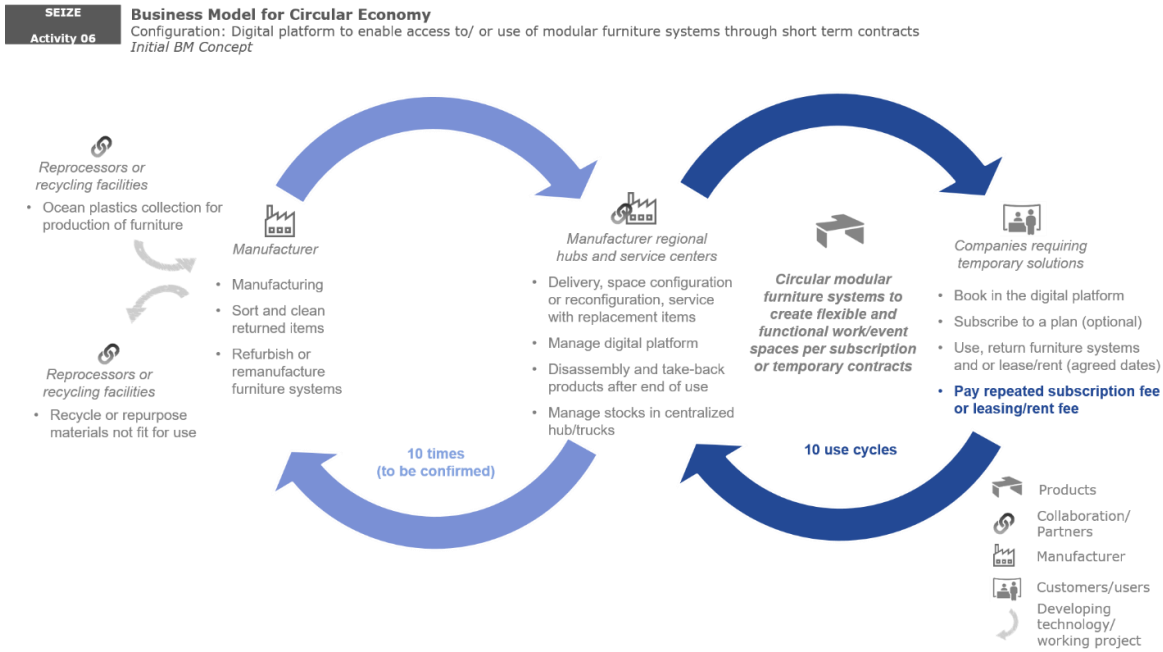


**Figure 3.** Value exchanged among actors in the initial BM configuration designed by Ope.

Lastly, during the third workshop, Ope applied Module 4 to evaluate the potential outcomes of the proposed PSS BM concepts (Table 2). This module, which is one of the main contributions of this paper, provides the opportunity for companies to check the affinity of the proposed concepts with CE outcomes, so they can either improve the concept or decide to start the design/configuration of another concept. It is important for allowing discussions and reconsideration about strategic choices

(e.g., differentiation, pricing, and segmentation) in order to guarantee the simultaneous economic and environmental gains to the largest extent possible.

**Table 2.** Potential CE outcomes for Ope. Legend: Dark circle—Requirement is fulfilled; Partial dark circle—Require further investigation or mitigation; Clear circle—Requirement is not fulfilled (developed from Kjær et al. [17], Kravchenko et al. [58], Pieroni et al. [9]).

| **PSS BM concept** | **Digital platform to enable access to/or use of modular furniture systems through short-term contracts (rental, leasing, or subscription).** | |
|---|---|---|
| **Segment/customers** | **B2B (e.g., project-based organizations, offices, event venues)** | |
| | **Requirement is fulfilled when . . .** | **Results:** |
| PSS → Economic growth | | |
| Ensure acceptable net profit ● | . . . profit enabled by new BM concept > = (at least equal to) long-term profit of current business model. | Return on investment, net present value and profit margins (including profit per asset/product) for different subscription, leasing fees, and contract periods were calculated. This helped to adjust a feasible subscription/leasing fee to enable at least a comparable or superior profitability to current BM (in the long term). Pricing definition also considered customer needs/expectations. |
| Foresee and mitigate investment requirements ◐ | . . . breakeven of the new BM concept occurs in an acceptable period, and if external financing capital is necessary it is also available. | Although profitable (positive return on investment), the concept incurs in a delayed breakeven of 10 years. *Mitigation:* Investigation of scenarios for cofinancing of this solution with the participation of investors in the first years. |
| Adjust for and mitigate upscaling challenges ◐ | . . . volume of returning products (for recirculation) justifies/pays off the required investments. This involves dealing with economies of scale. | The estimated return of products and volumes of sales do not pay off investment in refurbishing facilities and marketing campaigns required for launching this concept (i.e., negative return on investment in the first decade). *Mitigation:* This concept will be offered in metropolis to guarantee enough volume. |
| PSS → Superior customer value | | |
| Ensure added benefits and avoid or mitigate sacrifices ○ | . . . added benefits for customers > (are perceived as higher than) added sacrifices in relation to current BM. | Considered added benefits: lower investment costs; simplicity of concept; flexibility to renew furniture constantly. Sacrifices: B2B is used to procure comprehensive furniture packages, with a diversified portfolio to fulfil an entire workspace. As sacrifices are considered larger than benefits, this criterion was not fulfilled. *Mitigation:* apply the concept for events (e.g., industry fairs) and with the new products being developed. Suitable characteristics: they are not a niche product; would be less affected by changes of taste and fashion than the current product; could be maintained in the event venues for multiple uses; combined with the modular systems they would fulfil the key needs of event participants. |
| PSS → Absolute resource decoupling (effectiveness and efficiency) | | |
| Ensure net resource reduction ● | . . . resources needed for needs fulfilment without subscription > (are higher than) resources needed for needs fulfilment with subscription. | 20–45% potential resource reduction (calculated with indicator utility [1]; due to no need to produce new products). *Opportunities for improvement in other concepts:* not possible to capture the 'full circularity potential' of the product (could be used/refurbished for 10 cycles, but it is reaching 2 cycles in this configuration) imposed by market requirements regarding the time taken for products to be returned back and made available for new contracts. |
| Avoid burden shifting between life cycle stages ● | . . . "additional resources are not required during production and end-of-life." | The furniture needs to be designed for easy disassembly and high durability. However, since modular product design was already part of the incumbent BM, this could help avoid burden shifting. One potential risk is shifting the burden to the end-of-life by substituting the current raw material MDF to ocean plastics, in case that recyclability of the latter is not possible. |
| Mitigate rebound effects ◐ | . . . "value-adding low-resource intensive services mitigate or exceed any potential costs-savings." | By not having the upfront investment, customers (especially in the case of offices or project-based organizations) could spend these savings with other resources. *Mitigation:* this could be absent in the case of events' solutions because currently, the venue owners are not necessarily the owners of modular furniture/materials for space creation of stands. |

[1] Calculation of indicator 'Utility' based on Azevedo et al. [59].

Although the *resource decoupling potential* for the proposed BM concept showed positive results, the *customer value criteria* were not fulfilled. Ope judged that the sacrifices perceived by the customers with the proposed concept, i.e., the need for full-office solutions with a diversified furniture portfolio, would surpass their perception of added benefits, leading to a low perceived value. Moreover, even though positive, profitability would occur in the long term, which would require capacity of investment and scalability that were not considered as feasible by Ope.

Based on this assessment (Table 2), Ope concluded that the evaluated BM concept could work more adequately when the new product is ready for launching, since it will be directed to events with considerably shorter use cycles (e.g., ranging from days to a couple of weeks) and could compose synergy with the current products. It was discussed that venue owners could act as partners and potentially share investment and profits to offer the solution for participants (e.g., companies attending the events and in need of organizing their presentation stands/spaces). Hence, a new BM configuration was designed using modules 3 and 4. In relation to the previous BM concept (Figure 3), the new BM concept would be limited to the scope of event spaces/solutions. Participants of the events would have the possibility of booking, using, and paying-per-use (days, weeks) of full preconfigured spaces. Event organizers and venue owners interested in providing this solution for their customers (i.e., event participants) without putting too much effort into services would be able to request the system for their venues by paying a deposit for the initial stocks. As in the previous concept, the systems could be used ten times before being collected and taken by the manufacturer to regional refurbishment/remanufacturing centers. For the manufacturer, this configuration would require less effort with logistics and facilitate scalability.

#### 3.2.2. Action Research Cycle B

Based on the learnings from Cycle A, the application of module 1 was altered for Vestre in order to facilitate the combination of different BM patterns and adaptation to make sense for the company's context. After the identification of *BM Opportunities (patterns)* following Module 1 of the configurator, Module 2 was applied to support the combination of patterns and the generation of *Final BM ideas* (Table 3). Module 2 aims to achieve BM ideas (and subsequently concepts) with as much 'resource decoupling' as possible. Hence, it indicates likely combinations of patterns to guarantee value generation for CE in different stages of the life cycle (e.g., use, end-of-use, end-of-life) and both in the downstream (i.e., new revenue schemes and customer interface) and upstream (i.e., value creation systems, such as product design, reverse logistics) BM architecture. For instance, 'BM Pattern 1' (Table 3) was combined with a pattern entitled 'Incentivized product return for next-life sales.' This implies implementing a buy-back scheme for products reaching the end-of-use but yet with the potential for further use (which could occur in six years for Vestre) in order to refurbish or remanufacture and resell them.

After the configurations, Vestre prioritized the BM ideas with the objective of identifying the ones to focus on the stage 'seize' (modules 3 and 4 of the configurator). A discussion and comparison of the configurations were carried out based on information (i.e., potential benefits for CE and sustainability, potential benefits for customers and potential impact in CE strategies) provided by the new version of the CE-Driven Business Model Configurator. Vestre prioritized 'Final BM ideas 1 and 3' (Table 3) because they require fewer changes in the company's current capabilities (i.e., they are either closely related to the current way of operating or with experiments already occurring). Opportunities requiring new partnerships or radical changes in capabilities (e.g., final BM idea 2 would require capabilities related to digital technologies) were planned for the future.

During the second workshop, Vestre applied the third module of the configurator and obtained two BM concepts. In configuration 1 (Figure 4), the customers (B2B or B2G) would be able to buy the furniture (either new or refurbished). On top of that, they could sign up for a continuous maintenance service package to extend the life of urban spaces. Finally, in the end-of-use, they could require pick-up or buy-back from the manufacturer, which would refurbish the furniture and make it available

for new sales. With the support of the configurator, Vestre identified new operational capabilities (Supplementary Materials: Figure S2) required to implement this concept. For value creation and delivery, Vestre will need to structure a system for taking back products at the end of use. This will require negotiations with actors in the current value chain. For instance, 'building contractors' who are responsible for executing urban landscape projects—and the ones installing new furniture or decommissioning existing ones—will have to be engaged in the solution and probably receive financial incentives. New logistic routes will have to be negotiated with transportation companies. Moreover, regional reprocessing facilities will have to be built or new partnerships with local refurbishment centers will have to be established. Lastly, Vestre will have to hire and develop a maintenance team (and the related skills) or collaborate with a network of service dealers.

**Table 3.** CE-oriented BM ideas for PSS generated by Vestre and complemented by combinations.

| Final BM Idea | Original Selected BM Pattern | Combined Patterns | Customer Value Potential | Structural Waste Source/Type | Decoupling Potential (Based on [17]) |
|---|---|---|---|---|---|
| 1—'Furniture for social meeting places to last a lifetime with services for life-extension … trade in or we pick up your used furniture for free.' | 1—Products with through-life care (product-oriented PSS) | Incentivized product return for next-life sales | 1st life: customer segments (especially B2B) requiring modernization or refurbishment of previously acquired products (30 years in use) or 'often' changes in aesthetics. 2nd or further lives: customer segments interested in 'greener choices' (e.g., public procurement). | Lack of solutions for life-extension; 'real' product-life shortened—i.e., consumption patterns/use causing inferior longevity (sometimes 6 years) than design specifications (over 20 years). | Reduce the need to produce new products to fulfil needs. |
| 2—'Furniture for social meeting places to last a lifetime with services for life-extension and efficient management of urban spaces … trade in or we pick up your used furniture for free.' | 2—Products with efficient maintenance management (product-oriented PSS) | 1—Products with through-life care (product-oriented PSS) + Incentivized product return for next-life sales | 1st life: customer segments (especially B2B) requiring modernization or refurbishment of previously acquired products (30 years in use) or 'often' changes in aesthetics. 2nd or further lives: customer segments interested in 'greener choices' (e.g., public procurement). | Lack of solutions for life-extension; 'real' product-life shortened—i.e., consumption patterns/use causing inferior longevity (sometimes 6 years) than design specifications (over 20 years) or lack of proper care (maintenance). | Reduce the need to produce new products to fulfil needs, and reduce the need for resources during use. |
| 3—'Best fit/ configuration furniture for social meeting spaces at a 'monthly maintenance budget.' | 3—Access-based solution (use-oriented PSS) | Own reverse operations (e.g., reprocess, refurbish for reuse in a new contract) | Customer segments (especially B2G) requiring solutions with lower up-front investment; available budget for maintenance or operational expenses. Or, customer segments (B2C) requiring changes in aesthetics. | 'Real' product-life shortened—i.e., consumption patterns/use causing inferior longevity (sometimes 6 years) than design specifications (over 20 years). | Reduce the need to produce new products to fulfil needs. |

Configuration 2 (Figure 5) targets B2G customers with restrictions on their investment budget. Customers could benefit from obtaining the use of furniture or urban spaces solutions in a lease scheme. This solution would include continuous maintenance services from Vestre, as well as take-back at the end-of-contract. Additional new operational capabilities are required for this configuration (detailed in Supplementary Materials: Figure S3). For value creation and delivery, beyond the new capabilities previously mentioned for configuration 1, Vestre will have to review its sales model and create standard contracts with service level agreements.

During the third workshop, Vestre applied Module 4 to evaluate the potential outcomes of the proposed PSS BM concepts (Tables 4 and 5).

Although the *resource decoupling potential* and *business profitability* for configuration 1 (Table 4) showed positive results, some improvement opportunities were identified as a means to mitigate the risks for the BM concept regarding the fulfillment of customer value, the avoidance of rebound effects and burden shifting for other life-cycle stages, and the existence of favorable upscaling conditions.

The mitigation actions would rely on establishing collaborative/strategic partnerships, as well as reviewing considerations (trade-offs) for product design and pricing strategies.

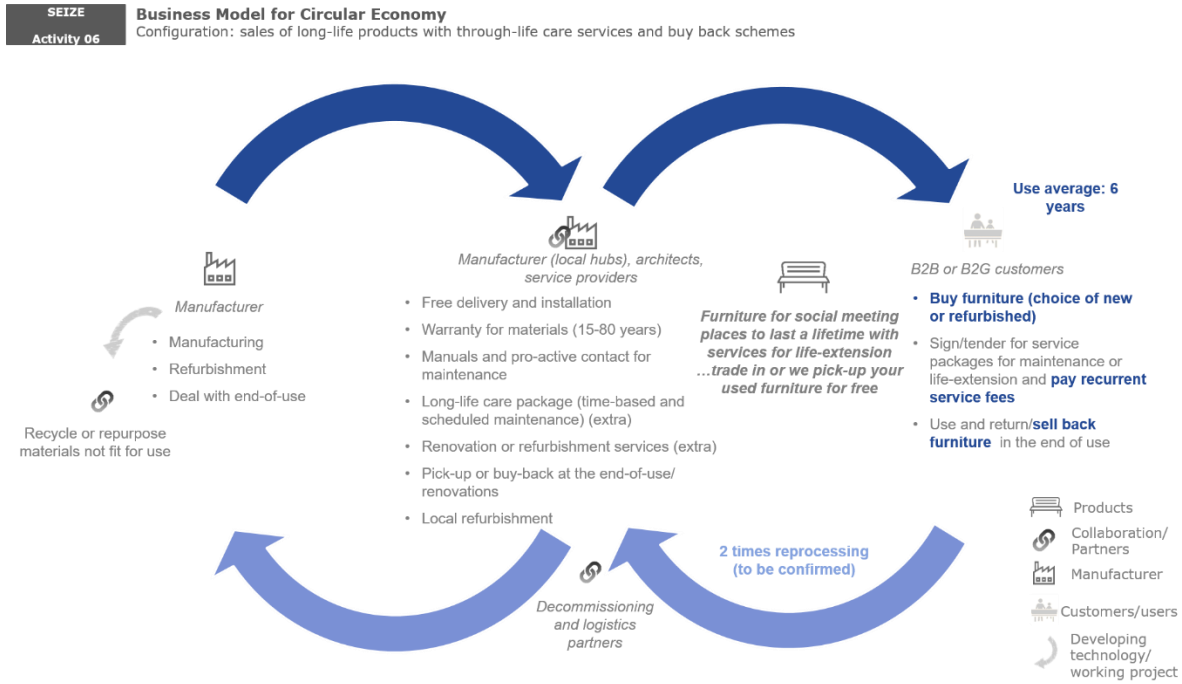


**Figure 4.** Value exchanged among actors in Vestre's BM configuration 1 (from BM idea 1).

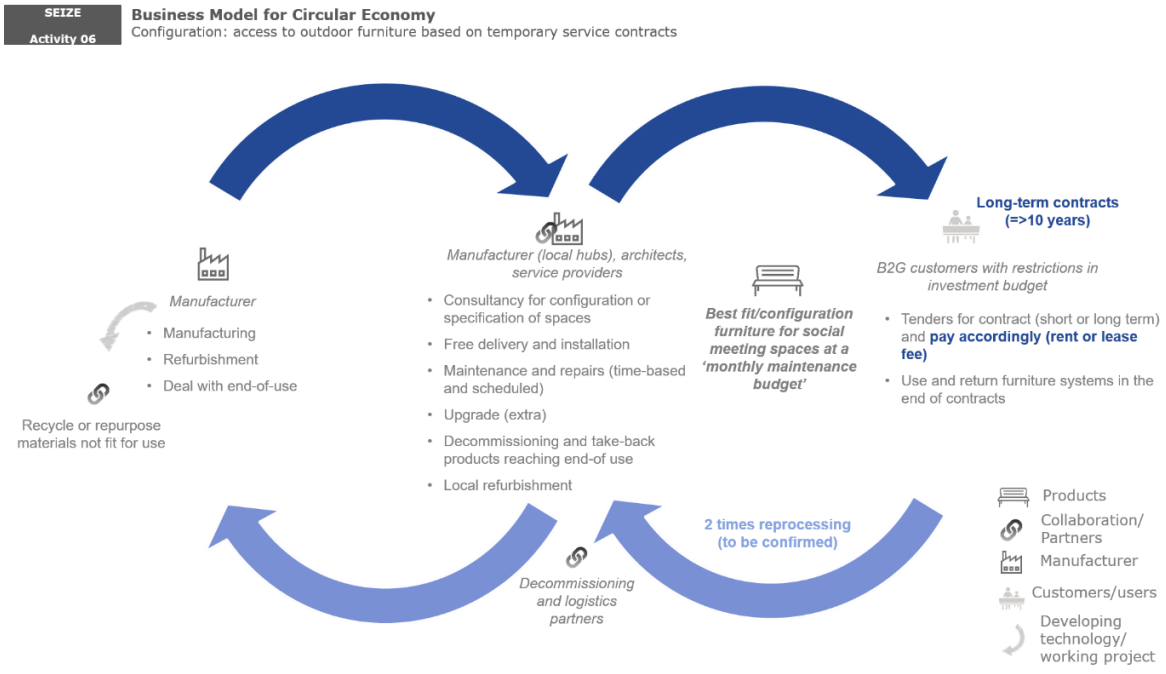


**Figure 5.** Value exchanged among actors in Vestre's BM configuration 2 (from BM idea 3).

**Table 4.** Potential CE outcomes for Vestre's BM Concept 1. Legend: Dark circle—Requirement is fulfilled; Partial dark circle—Require further investigation or mitigation; Clear circle—Requirement is not fulfilled (developed from Kjær et al. [17], Kravchenko et al. [58], Pieroni et al. [9]).

| **PSS BM concept 1.** | **Sales of long-life outdoor furniture with through-life care services and buy-back schemes.** | |
|---|---|---|
| **Segment/customers** | **B2B and B2G** | |
| | **Requirement is fulfilled when . . .** | **Results:** |
| | PSS → Economic growth | |
| Ensure acceptable net profit ● | . . . profit enabled by new BM concept > = (at least equal to) long-term profit of current business model. | Return on investment, net present value and profit margins (including profit per asset/product) for different buy-back fees and an average of substitution were calculated. This helped to adjust a feasible price for products or services contracts to enable comparable profitability to current BM (in the long term). Pricing definition also took into consideration customer needs/expectations. |
| Foresee and mitigate investment requirements ● | . . . breakeven of the new BM concept occurs in an acceptable period for the company, and if external financing capital is necessary it is also available. | The concept presented an acceptable pay-back period for the company (around 6 years), but estimated costs have to be reviewed after negotiation with partners. |
| Adjust for and mitigate upscaling challenges ◐ | . . . volume of returning products (for recirculation) justifies/pays off the required investments. This involves dealing with economies of scale. | The volume of returning products is small to justify investments in refurbishing facilities. *Mitigation:* outsource or find local partners with the appropriate capabilities/techniques. |
| | PSS → Superior customer value | |
| Ensure added benefits and avoid or mitigate sacrifices ◐ | . . . added benefits for customers > (are perceived as higher than) added sacrifices in relation to current BM. | Considered added benefits: environmental conscious/compliant option for end-of-use; convenience to 'get rid of old furniture' at the end of use; lower controlled maintenance costs; affordable option/lower investment. Sacrifices: in the case of B2G, it could be complex to convince subcontractors to sort specific furniture from the projects (in the case of renovations) to take back. *Mitigation:* establish partnerships and implement attractive buy-back. |
| | PSS → Absolute resource decoupling (effectiveness and efficiency) | |
| Ensure net resource reduction ● | . . . resources needed for needs fulfilment without subscription > (are higher than) resources needed for needs fulfilment with subscription. | 7–28% potential resource reduction (calculated with indicators utility and longevity [1]; due to life-extension and no need to produce new products). |
| Avoid burden shifting between life cycle stages ◐ | . . . "additional resources are not required during production and end of life." | The furniture needs to be designed for easy disassembly. This could have an effect on durability. |
| Mitigate rebound effects ◐ | . . . "value-adding low-resource intensive services mitigate or exceed any potential costs-savings." | Rebound with the increased demand for resources could occur either if 2nd life furniture (refurbished or remanufactured) is perceived as of inferior functionality or if it is priced lower when compared to new ones [60]. In the discussed BM concepts, price differentiation was considered. *Mitigation*: prices should be equalized in the long term. |

[1] Calculation of indicators 'Utility' and 'Longevity' based on Azevedo et al. [59] and Franklin-Johnson et al. [61].

Configuration 2 (Table 5) fulfils more conditions than configuration 1 (Table 4). However, it is limited to a 'niche' customer segment, represented by specific municipalities with restrictions in investment budget. Moreover, the risks for implementing this configuration are higher than in configuration 1 and, likewise, the effort for executing the mitigation plans is also higher. For instance, in addition to the facilities for reprocessing taken-back furniture, configuration 2 would require hiring and training technicians or a local network of service providers responsible for the installation and maintenance. Additionally, from previous experience and initial experiments with this type of

business model, Vestre identified that reconsiderations of product design would be necessary to adapt products for easy assembly and in loco customizations (i.e., different urban landscape projects require adaptations in the installation procedures and slight modifications/adaptations of the products in loco).

**Table 5.** Potential CE outcomes for Vestre's BM Concept 2. Legend: Dark circle—Requirement is fulfilled; Partial dark circle—Require further investigation or mitigation; Clear circle—Requirement is not fulfilled (developed from Kjær et al. [17], Kravchenko et al. [58], Pieroni et al. [9]).

| **PSS BM concept 2** | **Access to outdoor furniture based on temporary service contracts.** | |
|---|---|---|
| **Segment/customers** | **B2G customers with restrictions in the investment budget**<br>**B2C customers with short-term projects or temporary spaces** | |
| | **Requirement is fulfilled when …** | **Results:** |
| PSS → Economic growth | | |
| Ensure acceptable net profit ● | … profit enabled by new BM concept > = (at least equal to) long-term profit of current business model. | Return on investment, net present value and profit margins (including profit per asset/product) for different contract periods and prices were calculated. This helped to adjust a feasible price for services contracts to enable comparable profitability to current BM (in the long term). Pricing definition also took into consideration customer needs/expectations. |
| Foresee and mitigate investment requirements ● | … breakeven of the new BM concept occurs in an acceptable period for the company, and if external financing capital is necessary it is also available. | The concept presented delayed pay-back period (around 9 years).<br>*Mitigation:* the company would self-finance initial projects for strategic purposes. |
| Adjust for and mitigate upscaling challenges ◐ | … volume of returning products (for recirculation) justifies/pays off the required investments. This involves dealing with economies of scale. | The volume of returning products is small to justify investments in refurbishing facilities during the beginning of the implementation.<br>*Mitigation:* outsource or find local partners with the appropriate capabilities/techniques. |
| PSS → Superior customer value | | |
| Ensure added benefits and avoid or mitigate sacrifices ● | … added benefits for customers > (are perceived as higher than) added sacrifices in relation to current BM. | Considered added benefits: lower upfront investment; more value received to money; convenience; environmental conscious/compliant option for end-of-use.<br>Sacrifices: binding of 10-year contract (should not be critical). |
| PSS → Absolute resource decoupling (effectiveness and efficiency) | | |
| Ensure net resource reduction ● | … resources needed for needs fulfilment without subscription > (are higher than) resources needed for needs fulfilment with subscription. | 14–28% potential resource reduction (calculated with indicators utility and longevity [1]; due to life-extension and no need to produce new products). |
| Avoid burden shifting between life cycle stages ◐ | "additional resources are not required for production/end-of-life." | The furniture needs to be designed for easy disassembly. This could affect durability. |
| Mitigate rebound effects ● | "value-adding low-resource intensive services mitigate or exceed any potential costs-savings." | By not having the upfront investment, customers could spend these savings with other resources.<br>In the case of B2G, this is considered as a mitigated risk since they are already with 'limited budget for investment' upfront. |

[1] Calculation of indicators 'Utility' and 'Longevity' based on Azevedo et al. [49] and Franklin-Johnson et al. [51], respectively.

After analyzing the assessments, Vestre discussed how to work with both models in parallel to suit different customer segments, but without cannibalizing each other. They also discussed that configuration 1 should be the target for dissemination in the case that cannibalization is inevitable, mainly taking into consideration the market representativeness of customer segments.

## 4. Discussion

This section summarizes the results obtained with the application of the CE-oriented BMI Process and the CE-Driven BM Configurator to create PSS business model concepts for CE and discusses key findings in light of previous literature.

The focus of this article was to demonstrate how the application of the CE-Driven BM Configurator supported two Nordic furniture manufacturers in configuring (i.e., designing and assessing) PSS business models for CE. From a usefulness perspective, the CE-Driven BM Configurator showed positive results, supporting the manufacturers with fast ideation and simulation workshops providing knowledge about CE and PSS from external sources in an interactive and focused process. Formal feedback provided by individual participants in questionnaires indicates their satisfaction with the obtained results, with testimonials indicating that the configurator "made the process easier" and "has clarified and confirmed many choices that have been based on assumptions earlier." According to their opinion, strengths or differentials of the configurator are: "the use of examples from different industries to stimulate ideation," "interesting/great to see more/different cases/examples of companies experimenting with BMs for CE and the information of what works and trade-offs, also showing cases of discontinuation of initiatives." From the usability perspective, although enhancements were incorporated after the first AR, further improvements are required.

The results of this research are consistent with findings of previous literature [38,39], confirming common barriers or favorable conditions for the implementation of circular economy-oriented PSS in the furniture sector. The *common barriers* were:

- Breakeven delays with negative initial cash flow for access or use-oriented (pay-per-use or leasing) PSS (AR A and B) [38];
- Customer requirement of all-inclusive furniture portfolio/solutions (AR A) [39];
- Long usage time and technical simplicity of office furniture (AR A and B) [39];
- Applicability in regions where customers are geographically widespread (AR A) [39].

The common favorable conditions were:

- Potential customers are likely to be companies that have a lot of short-term project work (AR A) [39];
- Additional services could help improve the attractiveness of the PSS scenario to lock in customers (AR A and B—see Tables 1 and 3) [39].

Despite supporting some arguments from previous research, our findings show some nuanced positions. First, regarding market conditions and legislative/environmental practices identified by Besch [39], which reported a lack of willingness from customers to pay premium prices for environmentally superior products or services, and a lack of attention from manufacturers and incentives in the means of legislation. Fourteen years later since the application of the aforementioned research, this scenario seems to have changed as the companies in the AR cycles were motivated by a larger appeal for or pro-active requirement of environmentally friendly solutions coming from public procurement and customers. Although legislation is still lagging behind, environmental practices and public policies seem to be advancing, at least in the Nordic context.

Moreover, this research contributes to the literature by showing another approach for servitization in the context of CE than that commonly discussed in previous literature [6,15,38], which addresses the occurrence of product development initiatives for CE concurrently with the business model development of PSS. The manufacturers participating in the AR cycles of this research opted for configuring new PSS BMs with existing products, because they already presented characteristics in fit with CE (i.e., modularity for the case of Ope and durability for the case of Vestre). However, minor changes on the product are inevitable, as identified in previous research from the PSS [62] or CE [9,63] fields. Considerations regarding product design/development were triggered during the BM design process, which confirms the potential of the process model and the configurator in eliciting interdependencies with other business processes.

In addition to the confirmation or nuances with respect to previous literature, this research led to the identification of two additional key findings:

*Finding 1: The configuration of PSS business models should fulfil certain conditions (summarized in Figure 6) to contribute to circular economy and qualify as 'CE-Oriented PSS'.*

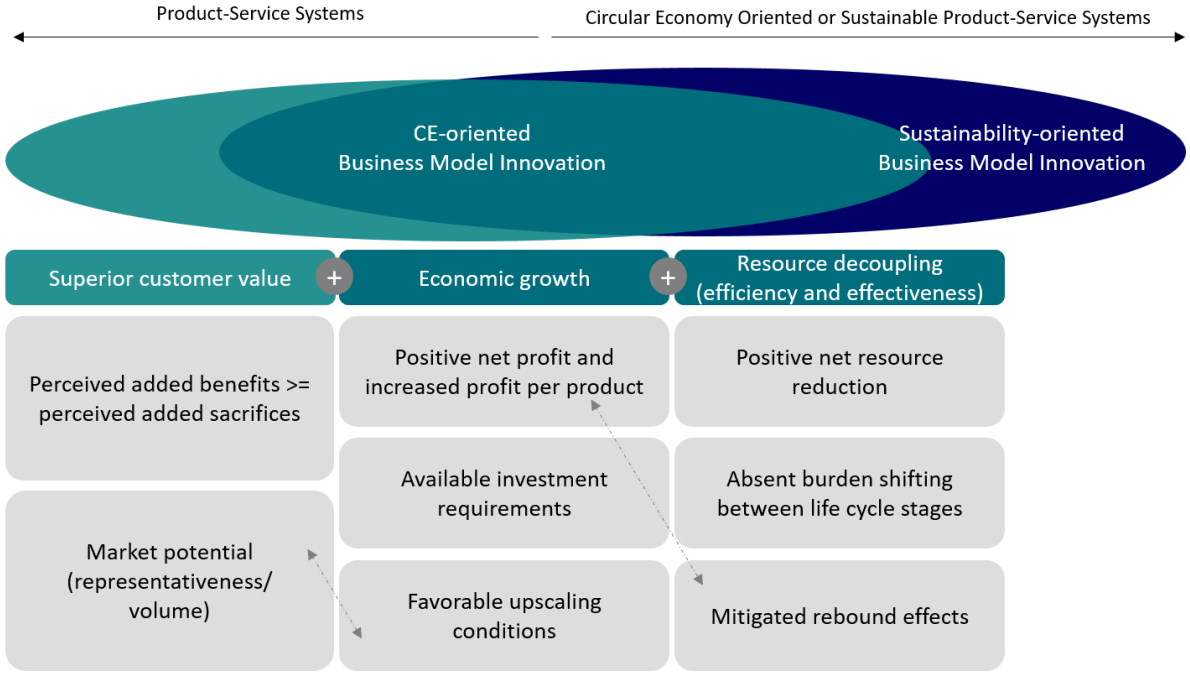


**Figure 6.** Conditions for creating 'CE-Oriented BMs based on PSS' (developed from Kjær et al. [15] and Pieroni et al. [6]).

As exemplified in the AR cycles, the configuration of CE-Oriented PSS business models involves identifying sources of structural waste in the current configurations, occurring simultaneously to new (and synergistic) customer needs, and being able to generate positive economic results for the company. The application of the framework (Figure 6) to assess the proposed PSS BM concepts demonstrated that trade-offs in the conditions are inevitable (indicated by dotted arrows), and that their reconsideration and balance can lead to the improvement of the circularity potential. For instance, environmental rebound effects (e.g., increased demand or consumption) can be mitigated by changes in the pricing strategy; or favorable upscaling conditions (i.e., existing infrastructure or possibility to invest on creating or accessing collection points, reverse logistics, or reprocessing facilities for the products and materials) can be facilitated by the correct selection of a market segment. One can argue that applying higher prices for avoiding rebound effects could bring difficulties for the company to withstand competition. Nevertheless, the additional perceived value enabled by the CE-offerings (i.e., new services) and changing customers' preferences towards sustainable solutions (e.g., in the case of Vestre, customers from the public sector were requiring ecofriendly solutions and willing to pay slightly more for it) could successfully compensate this.

*Finding 2: CE-Oriented PSS BMs are often (but not exclusively) 'niche solutions' in the sense that they fulfil very specific needs and customer segments, and are more likely to succeed with certain types of products or geographical locations.*

This finding could be considered a consequence of finding 1, which imposes many conditions to fulfil the three expected outcomes of CE. In Ope, *finding 2* was observed in the selection of a new product (or portfolio of products), a new customer segment (i.e., events participants and venue owners), and a delimited geographical region (i.e., large capitals) after the assessment of the PSS BM concept. 'AR cycle B' in Vestre also supported this finding, with the identification of a specific category of products (e.g., free-standing) for 'PSS BM Concept A.' Conclusions from Besch [39] about 'renting' BM concepts for office furniture also support *finding 2*. Moreover, other PSS BM concepts disseminated as good examples of CE initiatives in other sectors related to capital goods (e.g., Phillips Pay-Per-Lux [64]; Rolls Royce's Power-by-the-hour [65]) also support this finding, with the existence of 'one-of-its-kind' service contracts tailored for specific customers (e.g., Schiphol Airport [64]; Airbus or Boeing [65]) that represent a large revenue volume. Based on this finding, another condition was added to the category

'superior customer value' on top of the one evaluated in the case companies. This condition, entitled 'Market Potential,' is related to the existence of representativeness of a customer in terms of generated revenues (e.g., large contracts) or enough volume of several potential interested customers.

A final consideration is related to the decision-makers' choices for selecting ideas for new CE-oriented BM PSS. The case companies decided to implement less-complex CE-oriented BMs (sometimes with fewer environmental gains) as a way of seizing immediate results and being able to communicate their success in the short term. Two main reasons justified their decisions. First, the new capabilities required by these solutions would be realistic to achieve, despite already challenging for their context. Additionally, a successful implementation of these concepts could work as 'steppingstones' and help in convincing internal (e.g., sponsors and board members) or external actors (e.g., new investors, suppliers, new partners in the value chain, customers) that CE-oriented BMs can generate business results or additional value, and are worth expanding into more sophisticated solutions. Despite the fact that the CE-Driven BM Configurator offers a broad range of solution patterns (i.e., from more simplistic to more complex configurations) to prompt ideation, the decision-makers' ambitions in embedding CE principles to their BMs are key factors influencing or limiting the achievement of impactful environmental and economic outcomes [9,66]. This reinforces that the transition to CE through new business models is a learning process [67], which will require more than a tool, but a holistic and systemic approach of continuous change [9]. The CE-Oriented Business Model Innovation Process (Figure 1) [23] can support this aspect with an organizational framework to plan for continuous adaptation and change, instead of only treating innovation for CE as a 'single-shot' event.

## 5. Conclusions

This research aimed to guide organizations in configuring business model concepts for circular economy through the PSS approach. By means of action research, this article illustrated how PSS business model concepts for CE were designed and assessed by two Nordic furniture manufacturers with the application of a previously proposed conceptual process model and its main accompanying tool, the CE-Driven Business Model Configurator (documented in [3]).

Results demonstrate a positive uptake by the companies regarding the obtained outcomes. Based on the analysis of the research outcomes, two key findings regarding the configuration of CE-Oriented PSS business models were identified: (i) *the configuration of PSS business models should fulfil certain conditions to contribute to circular economy and qualify as 'CE-Oriented/Eco-PSS business models'*; and *(ii) CE-Oriented PSS BMs are often (but not exclusively) 'niche solutions' in the sense that they fulfil very specific needs and customer segments, and are more likely to succeed with certain types of products or geographical locations.* Connected to our first key findings, our key contribution is consolidated in a framework to support identifying *conditions for configuring 'CE-Oriented PSS business models.'*

This research contributes to the academic community in the intersection of business model innovation, PSS and CE. Building on previous research, it advances knowledge about when (or under which conditions) PSS can lead to enhanced circularity. Regarding practical contributions, this research and, especially the CE-Driven BM Configurator, provides a solution for fast modelling and simulations of scenarios of different CE-oriented BM concepts based on PSS. This can benefit manufacturing companies that are planning to engage in CE through means of PSS and need to define where and how to start. Moreover, since the tool incorporates the learnings from the two aforementioned key findings, it can help manufacturing companies to focus on problem-solving for CE, instead of only trying out any type of PSS concept (which are not necessarily impactful for CE). In its current version, the configurator is limited to six industry sectors (i.e., agriculture and food, heavy machinery, electronics, furniture, medical devices, and textile); however it could be updated following the same procedure described in Section 2.2 to incorporate new sectors or even a generic version (i.e., with a trade-off of losing the sectorial specificity and level of details). The configurator is flexible in terms of customers segments, varying according to the predominance of success cases in each specific sector. In the furniture sector, for instance, the generated business model concepts could be applied for B2B, B2C, or B2G.

The key limitations of this research are the sample (i.e., number of companies) and time constraints for the generalization of assumption/verification of the long-term success of CE-Oriented PSS BM concepts. Future empirical work is required to test the findings with a broader group of manufacturing companies in different organizational contexts and industry sectors. Moreover, as both companies will continue to conduct additional experiments with the initially developed PSS BM concepts, adjustments and/or the selection of new concepts might occur. After further investigations, for instance, Ope has decided not to focus on the 'event solutions' since it would demand a complex system in terms of number of product components and add-on features to offer the expected complete solution. As an alternative, Ope is experimenting with another use-oriented PSS BM concept (i.e., modular furniture systems in a leasing scheme) for two active customers. Hence, a new round of interviews with the companies is required to explore how the CE-Driven BM Configurator can contribute to the implementation stage of the business model concepts. Lastly, the CE-Driven BM Configurator still requires further development (e.g., a more flexible/dynamic software; adjustment in the level of information in the design options; refinement in the logic of suggestion of patterns configurations).

**Supplementary Materials:** The following are available online at http://www.mdpi.com/2071-1050/11/13/3727/s1, Table S1: cases for the Furniture sector embedded in the CE-Driven Business Model Configurator, Figure S1: CE-oriented PSS BM concept for Ope, Figure S2: CE-oriented PSS BM concept for Vestre, configuration 1, Figure S3: CE-oriented PSS BM concept for Vestre, configuration 2.

**Author Contributions:** Conceptualization, M.P.P.P., D.C.A.P. and T.C.M.; Data curation, M.P.P.P.; Formal analysis, M.P.P.P.; Funding acquisition, D.C.A.P. and T.C.M.; Investigation, M.P.P.P.; Methodology, M.P.P.P. and D.C.A.P.; Project administration, M.P.P.P.; Resources, D.C.A.P. and T.C.M.; Software, M.P.P.P.; Supervision, D.C.A.P.; Validation, M.P.P.P., D.C.A.P. and T.C.M.; Visualization, M.P.P.P.; Writing—original draft, M.P.P.P.; Writing—review & editing, M.P.P.P., D.C.A.P. and T.C.M.

**Funding:** This research was funded by NordForsk, Nordic Energy Research, and Nordic Innovation under the Nordic Green Growth Research and Innovation Programme, grant number 83144.

**Acknowledgments:** This article is one of the outcomes of the research project CIRCit (Circular Economy Integration in the Nordic Industry for Enhanced Sustainability and Competitiveness). The authors would like to thank the CIRCit consortium—Research Institutes of Sweden (RISE), Technology Industries Finland, Innovation Center Iceland, Norwegian University of Science and Technology (NTNU) and colleagues from the Technical University of Denmark—for facilitating the engagement with companies and participating in enriching discussions about Circular Economy. Special thanks go to the participating companies Ope and Vestre and their engaged collaborators for the opportunity and cooperation that made this research happen.

**Conflicts of Interest:** The aforementioned funding institutions had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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